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Original article

The effect of preventive oral care on postoperative infections after head and neck cancer surgery

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ABSTRACT

Objective: This study aimed to investigate the incidence of postoperative pneumonia (PP) and surgical site infection (SSI) in head and neck cancer (HNC) patients and clarify the relationship between oral care and postoperative infection.

Methods: We conducted a retrospective observation survey based on the medical records of 209 HNC surgery patients managed at a University Hospital in 2016–2018. The incidence of PP and SSI were assessed in patients who underwent operations of the nose and paranasal sinuses to the larynx. Factors associated with PP and SSI in a univariate analysis were included in a multiple logistic regression analysis. A Cox proportional hazards model was used analyze the incidence of PP according to time after surgery. The present study was approved by the ethical review board of our Institute.

Results: The rates of PP and SSI in our study population were 20.5% and 23.0%. Operative time ($P < 0.01$), blood loss ($P = 0.004$), tracheostomy ($P < 0.01$), reconstruction ($P < 0.01$), and preoperative plaque control record (PCR) ($P < 0.01$) were significantly associated with PP. The PCR depicted the oral hygiene based on the percentage of plaque attached to the tooth neck. A multiple logistic regression analysis indicated that the incidence of PP was significantly higher in patients with PCR values of ≥50% after preoperative oral care (OR=10.174, 95% CI 2.14–48.32, $P = 0.004$). Tracheostomy ($P < 0.01$), reconstruction ($P = 0.044$), a lower preoperative albumin level ($P = 0.019$), and a lower preoperative hemoglobin level ($P < 0.01$) were significantly associated with SSI.

Conclusions: The incidence of PP among patients who received oral care was high in those patients with high PCR values, indicating the importance of increasing compliance to preoperative oral care.

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1. Introduction

Postoperative pneumonia (PP) and surgical site infection (SSI) are reported to be the main postoperative infections in patients after head and neck cancer (HNC) surgery [1,2]. In comparison to thyroid, salivary gland, and neck surgery, HNC surgery patients with operations involving the nose and sinuses to the larynx have a higher incidence of PP and SSI, with reported incidence rates ranging from 12.6–30.6% [1–3] and 21.3–45.0% [1,2,4–7], respectively indicating that these operation are associated with a relatively large number of postoperative complications.

The reported risk factors for PP and SSI include prolonged surgery [3,6], reconstruction [4], tracheotomy [5], a lower preoperative albumin level [7], and preoperative radiotherapy [8]. As a characteristic of HNC patients, it has been pointed out that the surgical wound is adjacent to the oral cavity, and that oral secretions may easily flow into the respiratory tract due to postoperative pain or a wound edema. The oral flora was reported to be associated with SSI in patients with HNC surgery [9,10]. Furthermore, relationships between pneumonia-causing bacteria and tongue-fixing bacteria, and between the tartar index and the occurrence of pneumonia in elderly patients have been reported [11]. For this reason, SSI and PP are likely to occur due to the oral bacterial flora after surgery. It has also been reported that the number of bacteria in the oral cavity after surgery when dental intervention was performed prior to surgery [12] and that the occurrence of PP could be reduced by performing preoperative expert oral care for patients with esophageal cancer [13].

Thus, we hypothesized that preoperative oral care would be effective for preventing postoperative infections in HNC patients. Few studies have examined the effects of preoperative oral care on the incidence of PP and SSI, which are the main postoperative infections in HNC patients. It was therefore considered meaningful to examine the preventive effect of preoperative oral care on the postoperative infection.

The objective of this study was to clarify the incidence of postoperative infections in patients after HNC surgery and to clarify the relationship between preoperative and postoperative oral care.

2. Patients and methods

2.1. Patient selection

We retrospectively examined the incidence of PP and SSI among 209 patients who underwent HNC surgery from September 2016 to August 2018 at Kyushu University Hospital. After the decision was made to perform surgery, it was explained to the patients that they would receive oral support from expert oral care team and that they could visit on a voluntary basis.

Patients who had undergone endoscopic surgery and those with a poor general condition (PS $\geq$4) were excluded from the present study.

2.2. Definitions of terms

2.2.1. Oral care

This refers to the removal of plaque and cleaning the mouth through expert oral hygiene procedures which are performed by dentists and dental hygienists or teaching patients how to perform self-care. Patients perform oral care themselves until the day of surgery.

In principle, expert oral care was provided four times: two times before surgery (within two weeks before surgery and on the day before surgery) and two times after surgery. During expert oral care, we prepared toothbrushes, tuft brushes, interdental brushes, and sponge brushes. Expert oral care was performed by both dentists and dental hygienists at the two dental outpatient visits prior to surgery. The patient was then educated on how to perform oral care for the period up until surgery. Preoperative oral care was performed by the patient, while postoperative oral care was performed by the nursing staff.

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2.2.2. PCR

The PCR depicts oral hygiene based on the percentage of plaque attached to the tooth neck. It is obtained by assessing the pattern left by a staining solution that adheres to teeth with plaque. First, all teeth in the oral cavity have the staining solution applied. Each tooth is then divided into four surfaces (buccal, lingual, mesial, and distal), and the number of tooth surfaces of the dyed neck is counted. Finally, the ratio of the number of stained tooth surfaces among all tooth surfaces is calculated.

PCR calculation method = number of tooth surfaces with plaque attached / total number of surfaces $\times$ 100 (%)

According to a survey by Axelsson et al. [14], the PCR at the time of the dental visit was reported to be 50%−60%, so we suspected that the effectiveness of oral hygiene guidance could be evaluated in this manner.

2.3. Data collection

Patient characteristics, oral health factors, surgical factors, and nutritional factors were collected from medical records. For the plaque control record (PCR), which evaluates the plaque adhesion status in the oral cavity, two preoperative values (Time 1 and Time 2) and the value based on the postoperative data (average postoperative day 16.8).

2.4. The diagnosis of PP and SSI

1) PP was diagnosed based on the following diagnostic criteria.
   The evaluation period was the period until the start of oral ingestion after surgery. Respiratory symptoms such

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as fever and cough were observed. Pneumonia was suspected based on chest X-ray findings and diagnosed by a physician.

2) SSI was diagnosed based on the CDC diagnostic criteria.
Infectious diseases in which at least one of the following symptoms occurred within 30 days following surgery: (1) purulent exudate and drainage from the wound, along with purulent drainage from the indwelling drain; (2) pathogens isolated from specimens aseptically collected from the wound; (3) at least one sign or symptom of the following infections: fever (>38 °C), localized pain, or localized tenderness, wherein this criterion was not met if the culture was negative; (4) evidence of an abscess or other infection found by direct search, during repeat surgery, histopathology, or radiological examination; and (5) a diagnosis of SSI by the surgeon or attending physician.

2.5. Statistical analyses

The basic information and rate of infection were shown as the mean, standard deviation (SD), and percentage. Pearson's chi-squared test or Fisher's exact test were performed to analyze the relationship between each variable and PP and SSI. Continuous variables were classified into two groups and verified. Factors significantly associated with PP or SSI in a univariate analysis were included in a multiple logistic regression analysis.

Intraoral PCR deficit values were processed by the average substitution method and the Wilcoxon signed rank test was used to compare PCR values prior to oral care intervention (Time 1) to those after preoperative oral care intervention (Time 2) and after postoperative oral care intervention (Time 3). The incidence of PP according to the time after surgery was analyzed using a Cox proportional hazards model. The cumulative incidence of PP was shown using Kaplan–Meier estimates and then the patients were divided into 2 groups and any differences were identified by the log rank test.

All statistical analyses were performed using SPSS version 24.0 (IBM, Chicago) for Windows. *P*values of <0.05 were considered to indicate statistical significance.

This study was approved by the Kyushu University Certified Institutional Review Board of Clinical Trials (Approval No. 28–205). The study subjects gave their written informed consent.

3. Results

3.1. Patient background factors

During the survey period, 209 subjects were used for analysis. The incidence of PP was 12.4%, while that of SSI was 13.9%. The objective of this study was to limit the occurrence of PP and SSI to patients who underwent upper respiratory tract surgery. Thus, we analyzed the effects of oral care in 122 patients (male, 76.2%; average age 67 years; range 28–86 years) who underwent operations involving the nasal and paranasal sinus, oral cavity, pharynx, and larynx. Patients who underwent procedures involving the neck, thyroid, and salivary glands were excluded from the present study. In this study population, 66.4% of the patients were smokers, and 59.0% reported that they drank alcohol (Table 1).

Table 1
Preoperative and surgical of the characteristics, $N = 122$.

Variables	n (%) or mean ± SD, Median [range]
Characteristics	
Age (years)	67.0 ± 11.1, 69.0 [28–86]
Gender	
Male	93 (76.2)
Female	29 (23.8)
BMI (kg/m^2)	20.4 ± 3.3, 20.7 [14–29]
Smoking	81 (66.4)
Alcohol	72 (59.0)
Diabetes mellitus	16 (13.1)
Preoperative treatments	
Preoperative chemotherapy	56 (45.9)
Preoperative radiation therapy	35 (28.7)
Preoperative oral steroids	3 (2.5)
Preoperative factors	
Preoperative albumin (g/dl)	3.9 ± 0.6, 3.9 [2.4–5.0]
Preoperative hemoglobin (g/dl)	12.3 ± 1.7, 12.3 [7.9–15.4]
Preoperative total protein (g/dl)	6.4 ± 0.6, 6.7 [4.8–8.0]
Preoperative oral care	73 (59.8)
Surgical factors	
Operation time (min)	471.1 ± 246.6, 504.5 [28–992]
Blood loss (ml)	381.3 ± 372.9, 319.0 [1–2350]
Tracheostomy	81 (66.4)
Reconstruction	81 (66.4)

BMI: Body mass index.

Table 2
Incidence of PP and SSI according to surgical site.

Surgical site	Overall 122	PP (%) 25 (20.5)	SSI (%) 28 (23.0)
Nasus–Paranasal	23	6 (24.0)	3 (10.7)
Oral cavity	58	14 (56.0)	10 (35.7)
Pharynx	28	5 (20.0)	9 (32.1)
Larynx	13	0	6 (21.4)

PP, Postoperative pneumonia; SSI, Surgical site infection.

3.2. Incidence of PP and SSI

The incidence rates of PP and SSI were 20.5% (incidence days 2–18) and 23.0% (incidence days 2–22), respectively. The most common surgical site was the oral cavity, followed by the larynx. The oral cavity was associated with the highest incidence of PP (56.0%). None of the patients who underwent operations involving the pharynx developed PP. The oral cavity was the surgical site associated with the highest incidence of SSI (35.7%) (Table 2).

3.3. The analysis of factors associated with PP and SSI

In the univariate analyses, the following factors showed an association with PP: operative time ($P < 0.01$), blood

Table 3
Risk factors for PP and SSI according to univariate analyses, $N = 122$.

Variables	PP			SSI		
	Yes $n = 25$ (%)	No $n = 97$ (%)	P value	Yes $n = 28$ (%)	No $n = 94$ (%)	P value
Operation time						
≥670 min	12 (41.4)	17 (58.6)	<0.01	10 (34.5)	19 (65.5)	0.091
<670 min	13 (14.0)	80 (86.0)		18 (19.4)	75 (80.6)	
Blood loss						
≥380 ml	17 (32.7)	35 (67.3)	0.004	15 (28.8)	37 (71.2)	0.182
<380 ml	8 (11.4)	62 (88.6)		13 (18.6)	57 (81.4)	
Tracheostomy						
Yes	23 (28.8)	58 (71.6)	<0.01	27 (33.3)	54 (66.7)	<0.01
No	2 (4.9)	39 (95.1)		1 (2.4)	40 (97.6)	
Reconstruction						
Yes	24 (29.6)	57 (70.4)	<0.01	23 (28.4)	58 (71.6)	0.044
No	1 (2.4)	40 (97.6)		5 (12.2)	36 (87.8)	
Preoperative albumin						
<3.5 g/dl	8 (28.6)	20 (71.4)	0.228	11 (39.3)	17 (60.7)	0.019
≥3.5 g/dl	17 (18.1)	77 (81.9)		17 (18.1)	77 (81.9)	
Preoperative hemoglobin						
<12 g/dl	12 (16.9)	59 (83.1)	0.246	18 (35.3)	33 (64.7)	<0.01
≥12 g/dl	13 (25.5)	38 (74.5)		10 (14.1)	61 (85.9)	
Preoperative oral care						
Yes	12 (16.4)	61 (83.6)	0.176	14 (19.2)	59 (80.8)	0.226
No	13 (26.5)	36 (73.5)		14 (28.6)	35 (71.4)	
Residual teeth($N = 73$)						
<20	5 (13.9)	31 (86.1)	0.562	10 (27.8)	26 (72.2)	0.066
≥20	7 (18.9)	30 (81.1)		4 (10.8)	33 (89.2)	
PCR at post intervention before surgery ($N = 73$)						
≥50%	9 (42.9)	12 (57.1)	<0.01[a]	6 (28.6)	15 (71.4)	0.166[a]
<50%	3 (5.8)	49 (94.2)		8 (15.4)	44 (84.6)	

P value for Pearson's chi-squared test, PP, Postoperative pneumonia; SSI, Surgical site infection; PCR, Plaque control record.
[a] Fisher's exact test.

loss ($P = 0.004$), tracheostomy ($P < 0.01$), reconstruction ($P < 0.01$), and preoperative PCR ($P < 0.01$). The following factors were associated with SSI: tracheostomy ($P < 0.01$), reconstruction ($P = 0.044$), preoperative albumin ($P = 0.019$), and preoperative hemoglobin ($P < 0.01$). PP was more common in patients with PCR values >50%. PP was found in 9 in patients with PCR values> 50% and in 3 patients with <50% PCR values (Table 3). Multiple logistic regression analysis was performed to adjust for confounding factors. As a result, PCR values ≥50% after preoperative oral care intervention was identified as a significant factor (OR = 10.174, 95%CI 2.14–48.32, $P = 0.004$). No variables were significantly associated with SSI (Table 4).

3.4. Effects of oral care on other factors

We analyzed the effects of the presence or absence of oral care on variables that showed significant associations with the occurrence PP and SSI. The only significant difference was the operation time. No significant differences were observed regarding blood loss, tracheostomy, reconstruction, preoperative albumin levels and preoperative hemoglobin levels (Table 5).

3.5. A comparison of the intraoral PCR values before and after surgery

PCR values significantly ($P < 0.01$) decreased from before oral care intervention (Time 1) to after preoperative oral care intervention (Time 2). PCR values also significantly decreased from preoperative oral care intervention to after postoperative oral care intervention (Time 3) ($P < 0.01$) (Fig. 1).

3.6. Cumulative incidence of PP

The cumulative incidence of pneumonia, as estimated by the Kaplan–Meier method, differed between patients with PCR values of ≥50% and those with PCR values of <50% after preoperative oral care intervention ($P < 0.0001$). The cumulative incidence of PP in patients with PCR values of ≥50% after preoperative oral care interventions was higher than that in patients with PCR values of <50%. Furthermore, patients with PCR values of ≥50% tended to develop PP early after surgery (Fig. 2).

4. Discussion

In the present study, the incidence rates of PP and SSI in patients who underwent HNC operations involving the nasal

Table 4
Multiple logistic regression analysis of the factors associated with PP and SSI, $N = 73$.

Clinical factors	PP			SSI		
	OR	95%CI	*P* value	OR	95%CI	*P* value
Operation time ≥670 min	1.638	0.15–17.38	0.682	1.82	0.20–16.60	0.596
Blood loss ≥380 ml	0.605	0.08–4.63	0.629	0.53	0.12–4.56	0.756
Reconstruction	0.255	0.02–3.54	0.309	0.7	0.29–26.31	0.723
Tracheostomy	0.983	0.11–8.50	0.988	–	–	–
PCR at post intervention before surgery ≥50%	10.174	2.14–48.32	0.004	0.61	0.32–5.59	0.697
Preoperative albumin <3.5 g/dl	0.277	0.03–2.49	0.252	0.25	0.60–29.87	0.148
Preoperative hemoglobin <12 g/dl	1.24	0.23–6.74	1.237	0.52	0.14–2.91	0.560

PP: Postoperative pneumonia, SSI: Surgical site infection, PCR: Plaque control record.

Table 5
Univariate analysis of the effects of oral care on preoperative risk factors, $N = 122$.

Variables	Oral care		
	Yes $n = 73$ (%)	No $n = 49$ (%)	*P* value
Operation time			
≥670 min	12 (41.4)	17 (58.6)	0.020
<670 min	61 (65.6)	32 (34.4)	
Blood loss			
≥380 ml	30 (57.7)	22 (42.3)	0.677
<380 ml	43 (61.4)	27 (39.6)	
Tracheostomy			
Yes	46 (56.8)	35 (43.2)	0.335
No	27 (65.9)	14 (34.1)	
Reconstruction			
Yes	48 (59.3)	33 (40.7)	0.855
No	25 (61.0)	16 (39.0)	
Preoperative albumin			
<3.5 g/dl	13 (46.4)	15 (53.6)	
≥3.5 g/dl	60 (63.8)	34 (36.2)	0.099
Preoperative hemoglobin			
<12 g/dl	29 (56.9)	22 (43.1)	0.570
≥12 g/dl	44 (62.0)	27 (38.0)	

P value for Pearson's chi-squared test.

and paranasal sinuses to the larynx (many of whom had oral cancer) were 20.5% and 23%, respectively. Among the patients who received oral care, those with high PCR values had a higher rate of PP, while the incidence of SSI was affected by the surgical procedure and nutritional status.

The relationship between the factors causing PP and oral care is described here. The reported incidence of PP ranges from 12.6–30.6% [1–3]. Milet et al. [2] reported that the incidence of PP was 12.6%, which was lower than the rate in this study. The reason for this discrepancy was that the study subjects were more than 10 years younger than those in our study (median 56 years vs. 69 years) and that the operative time was shorter than that in our study (median: 180 min vs. 319 min). Furthermore, the percentage of patients undergoing reconstruction was also as low as 44%. After HNC operations at sites adjacent to the oral cavity, oral secretions may easily flow into the respiratory tract due to postoperative pain, wound edema, and other conditions. As a result, one study reported that tracheostomy with reconstruction is an important risk factor for PP [15]. Reconstruction and tracheostomy accounted were performed in 66.4% of our patients; thus, there was considered to be a high risk of developing PP in study population. Yeung et al. [3] reported a PP of 30.6%. The average age of target patients was 63.7 years, which was not significantly different from this study. However, 19% of the patients underwent operations lasting >12 h. The time under general anesthesia has been reported to be associated with the incidence of PP [16,17]; thus, prolonged surgery might have had an effect on the incidence of PP.

Although our study targeted HNC patients, oral care has been found to be effective for preventing PP in esophageal cancer patients [13,18] and lung cancer patients [19] Yamada et al. [5] observed the oral environment and reported on PP prevention. In their study, patients were divided according to their preoperative plaque rates. They found that the incidence of PP was significantly lower in patients with <33% preoperative plaque and in patients who received preoperative oral care. The PCR was used to observe and evaluate the oral environment in this study. PCR values of ≥50% after preoperative oral care intervention were associated with an increased incidence of PP. The mean PCR value after preoperative oral care intervention was 35.0 ± 3.4%. According to a report by O'Leary et al. [20] the target PCR for oral care was ≤20% and oral care by patients was considered to be insufficient. As illustrated in Fig. 2, PP frequently occurs within 10 days after surgery, indicating that the oral environment before and after surgery is important. This strongly suggests that plaque may be a reservoir for pneumococcal bacteria [21]; moreover, Wahlin [22] reported that physical removal with a toothbrush was effective for eliminating oral bacterial flora.

As illustrated in Fig. 1, the PCR values were significantly reduced and it was considered meaningful that professional oral care was provided. However, the comparison between Time 1 and Time 2 demonstrated that were patients whose values did not improve. Oral care was left up to the patient until the day prior to surgery and it was believed that compliance was insufficient. Going forward, the challenge will be to find a way to keep the oral cavity clean in order to prevent PP.

In previous studies, the incidence of SSI ranged widely from 21.3% to 45% [1,2,4–7]. In the study by Kamizono et al. [7], which reported the lowest incidence of SSI (21.3%), nurses performed oral cleaning with water flossers three times per day. Furthermore, a team of experts, including dentists, reduced the incidence of SSI in patients undergoing

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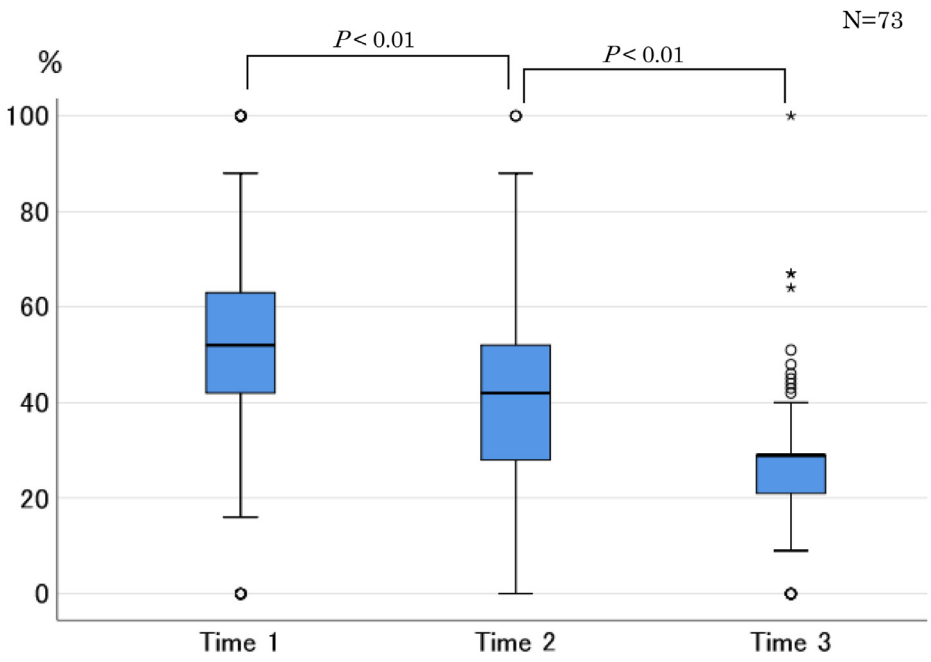
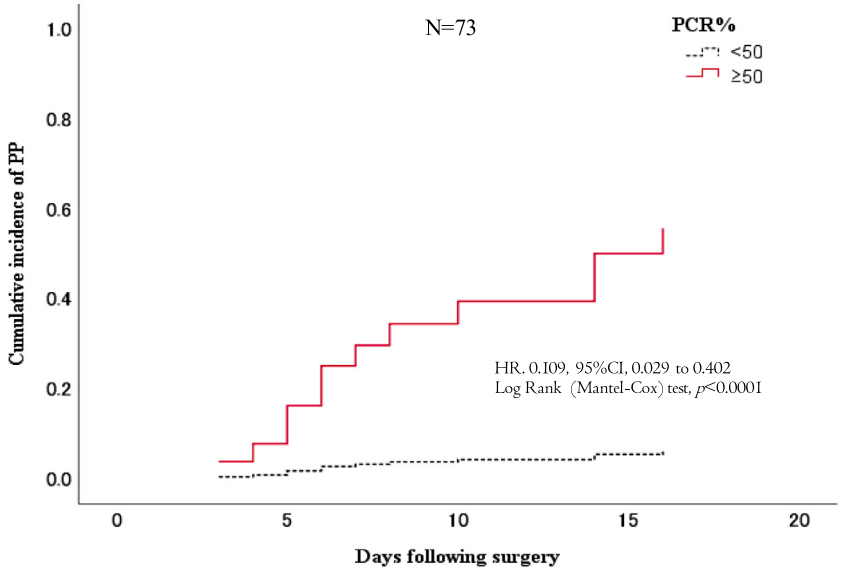


Fig. 1. PCR comparison of the 3rd period.
P value for Wilcoxon signed rank test, Time 1: Before oral care intervention, Time 2: After preoperative oral care intervention, Time 3: After postoperative oral care intervention after surgery. PCR: Plaque Control Record.



Number at risk				
PCR<50	52	52	50	49
PCR≥50	21	17	14	13

Fig. 2. Kaplan–Meier estimates of the cumulative incidence of pneumonia according to the PCR values after preoperative intervention.
Kaplan–Meier estimates confirmed that the incidence of both groups remained constant regardless of time. PCR: Plaque Control Record.

reconstruction to 24.2% [23]. The incidence of SSI in patients who underwent reconstruction in our study was 28.4%. This difference is considered to be due to the high proportion of chemotherapy and radiotherapy patients in our study population.

Reconstruction, smoking [4], tracheostomy [5], and lower albumin and hemoglobin levels [7] have been reported as causes of SSI. The univariate analyses demonstrated that, with the exception of smoking, the incidence did not differ to a statistically significant extent between patients with and without these factors. The incidence of SSI was affected by surgical procedures and nutritional factors.

The present study was associated with some limitations, including its retrospective design; thus, it was not possible match the age and gender of the subjects in the oral care support group and the non-oral care group. Furthermore, although

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the original study population was 209, when we targeted the upper respiratory tract (due to the limited onset of infectious disease), the number study population was reduced to 122. As a result, the number of patients receiving oral care decreased to 73. Finally, the objective of this study was to investigate the preventive effect of preoperative oral care on postoperative infection. However, while the PCR values were improved, variation in the effects of intervention were seen, likely because oral care depended on the self-care of the patient.

5. Conclusion

It was indicated that oral care before and after surgery is important to reduce postoperative infections in patients undergoing HNC surgery. It was suggested that intraoral flora was associated with the occurrence of PP and that surgical procedures and the nutritional status had an effect on the occurrence of SSI. We believe there is a need to provide all patients undergoing surgery with instructions on preoperative compliance with oral care.

Declaration of Competing Interest

The authors declare no conflicts of interest in association with the present study.

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